UNCLASSIFIED

SAB200132340000

~~SECRET/FRD~~

Tunnel Damage from Ground Shock (U)

Jon Rogers

Dept. 5412

June, 1997

M Buchanan 10/23/00

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW

1ST REVIEW-DATE: 2/23/99	DETERMINATION (CIRCLE NUMBER(S))
AUTHORITY: ☒DC ☐DD	1. CLASSIFICATION RETAINED
NAME:	2. CLASSIFICATION CHANGED TO:
	3. CONTAINS NO DOE CLASSIFIED INFO
2ND REVIEW-DATE: 12/1/00	4. COORDINATE WITH: DOD
AUTHORITY: DD	5. CLASSIFICATION CANCELED
NAME:	6. CLASSIFIED INFO BRACKETED
	7. OTHER (SPECIFY): DoE info CFRD

(DOE info in black)

~~Formerly Restricted Data~~
~~Unauthorized disclosure subject to Administrative and Criminal Sanctions. Handle as Restricted Data in Foreign Dissemination Section 144.b. Atomic Energy Act 1954.~~
~~Classified by A. G. Easterling Org 5412~~
~~Title ... Modeling & Analysis Date 12/1/97~~

~~SECRET~~

JDR:5412:6/6/97:tnldmg.ppt

UNCLASSIFIED

Sandia National Laboratories

1

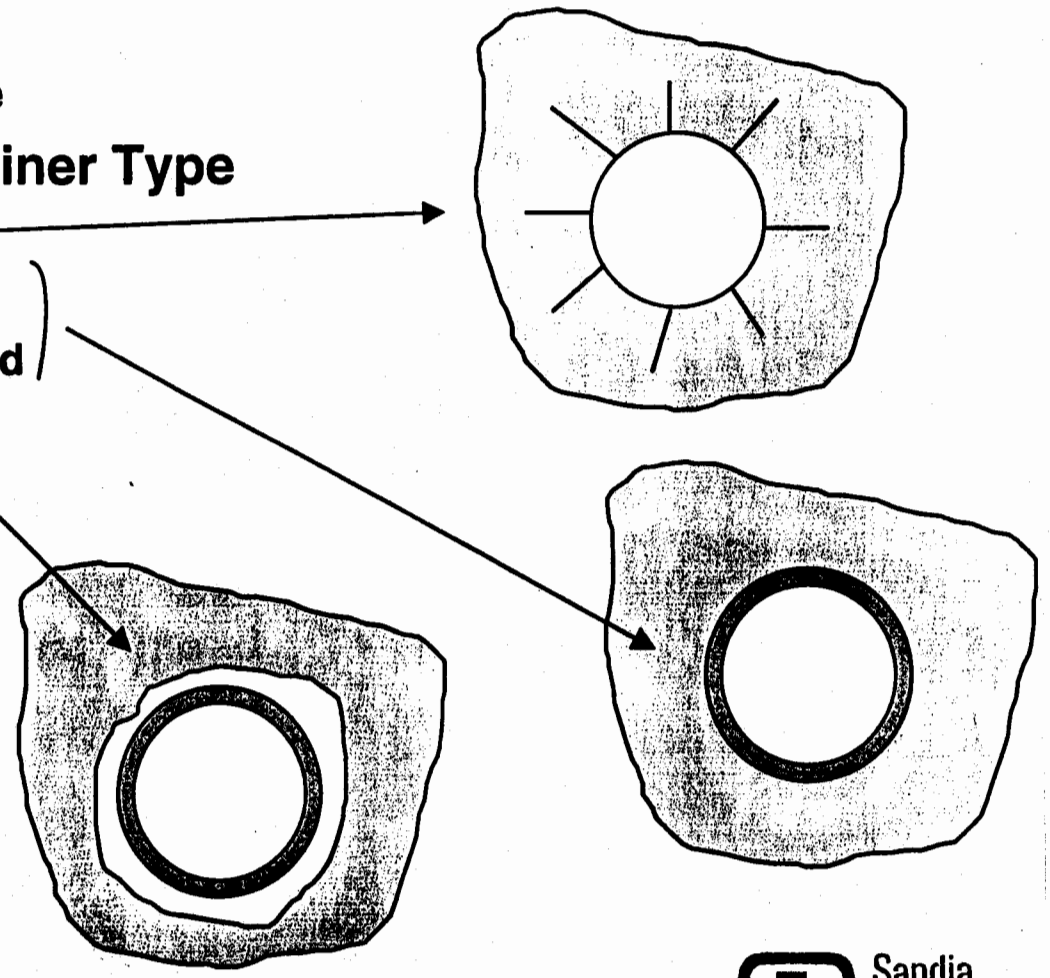
98SA20B000107

SNL-(97-180-5)-C-5400-1-2

(1)

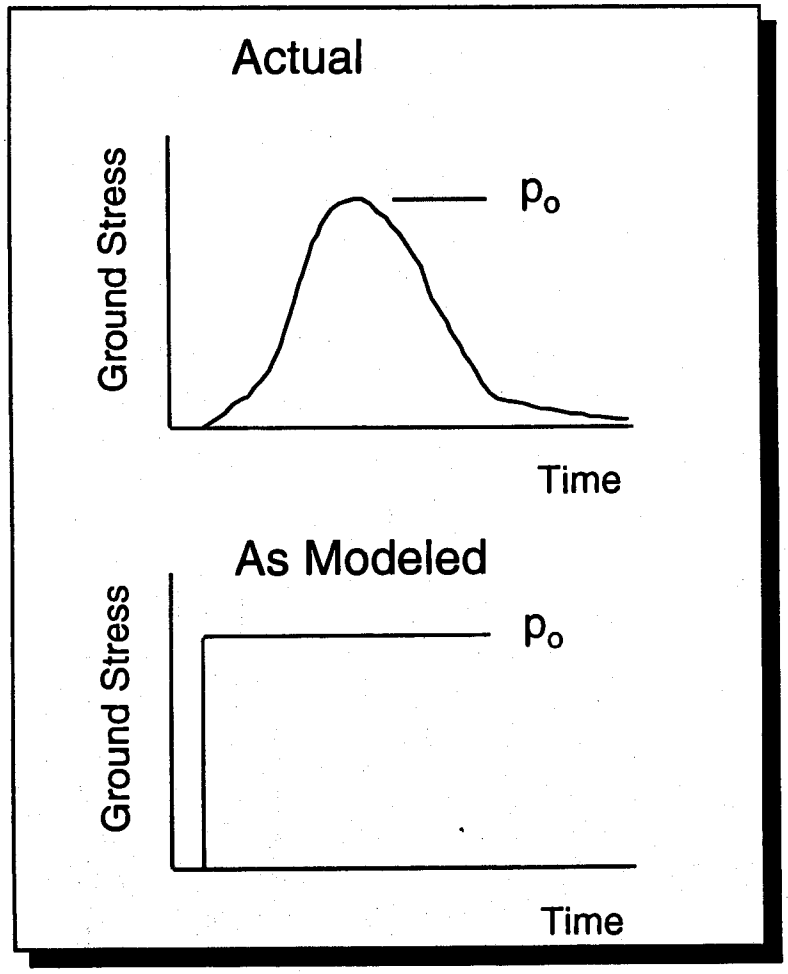
First Define the Tunnel (U)

- **Geology**
  - local to the site
- **Construction/Liner Type**
  - Rockbolted
  - Concrete lined
  - Composite lined
  - Backpacked



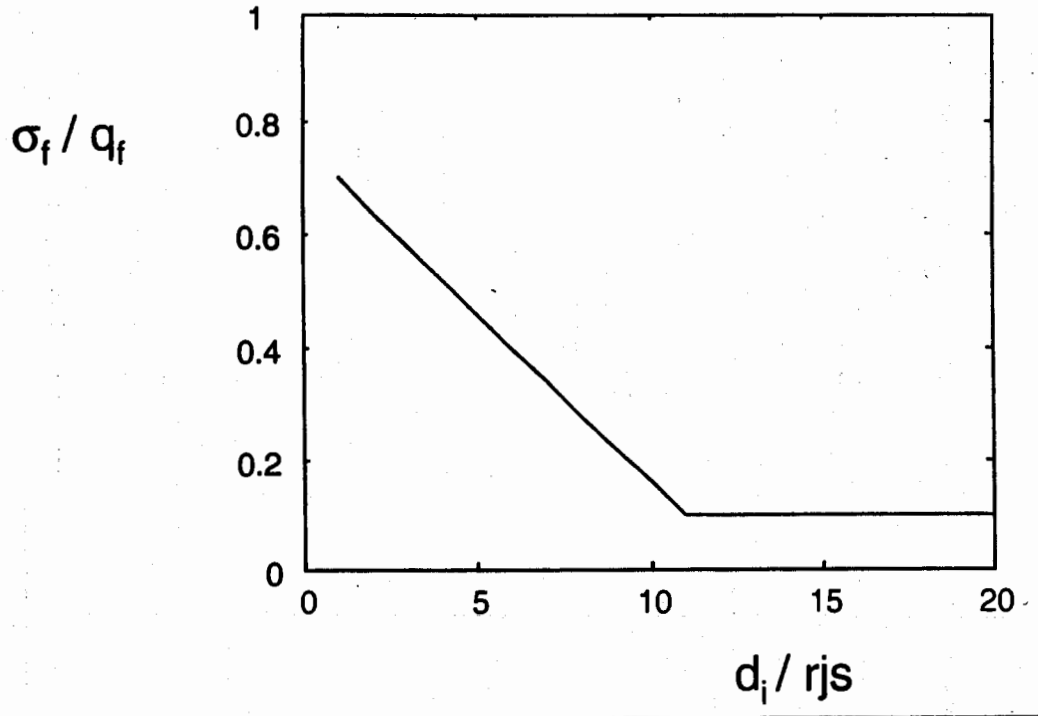
Hendron and Aiyer Analysis (U)

- **Published by Corps of Engineers in 1972**
  - Extension of work by Newmark (1969)
  - These are "Big Names" in Rock Mechanics
- **Assumes static loading**
  - Uniform external pressure, p_o
  - p_o is the maximum ground stress
  - Elastic/Plastic analysis with dilatency
  - Uses Coulomb-Navier failure criteria
- **Calculate Hoop Strain for a given external pressure**



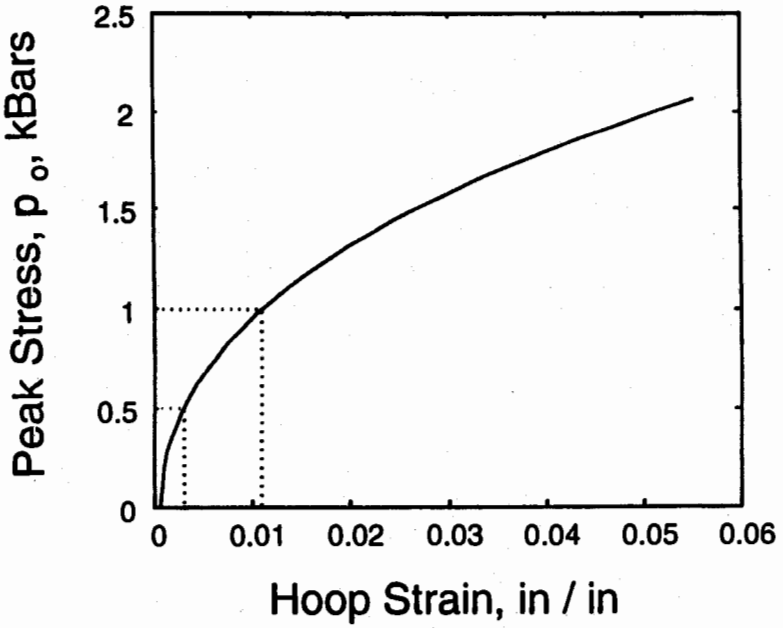
Hendron and Aiyer Analysis - Cont'd (U)

Use a Rock Strength Reduction Factor (SRF)



σ_f = in-situ rock strength
q_f = unconfined laboratory rock strength
rjs = rock joint spacing
d_i = rock opening diameter

Hendron and Aiyer Analysis Results (U)



- Curve Depends on:
  - Liner
  - Rock Properties
  - Tunnel Size
- Similar / Identical sections in different locations have different peak stresses (p_o) but the same curve.
  - Different hoop strains
  - Identify failure/survival strain
- Many issues to consider

Issues to Consider (U)

- **Dynamic loading effects**
  - Rock tends to be a lot stronger under dynamic loads than under static loads
  - Impulse versus peak load analysis
- **Liner/Rock interface not well modeled**
- **Test data come from 2 geologies**
  - Granite
  - Tuff
- **What are the inherent biases of the analysis?**

"Calibration" of Hendron and Aiyer Results (U)

- "Calibrated" for various construction types
  - Much of data from 3 UGTs
    - Piledriver and Hard Hat - tests in Granite
    - Mighty Epic - test in Tuff
  - Lots of tunnel sections and liner types, few large sections
    - Most sections 6 - 7 feet in diameter
    - Most sections loaded side-on
- Work was in support of Deep Basing (1983)
  - Goal was protection of U.S. assets
  - Focus was on "Sure Safe" design
    - Choose to err on the side of "defender conservative"

LDRD Project: Unexplored Penetrator Regime Against Super-Hard Underground Facilities

Part 2: Review of Tech Base Activities

Technical accomplishments: Abrasion model

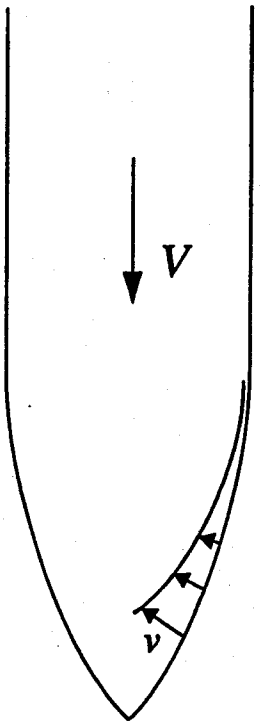
Sandia National Laboratories

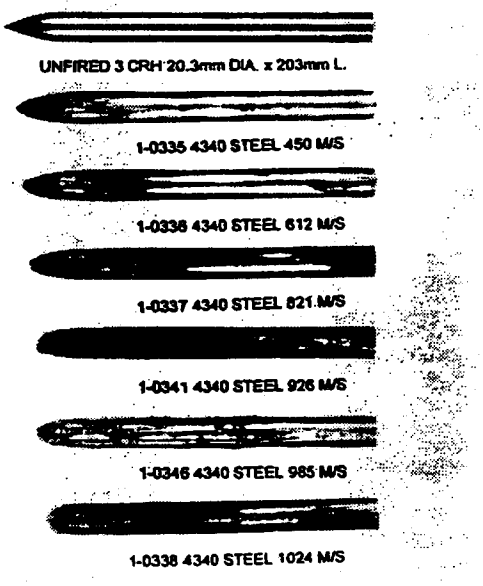
Computational Physics & Mechanics Department

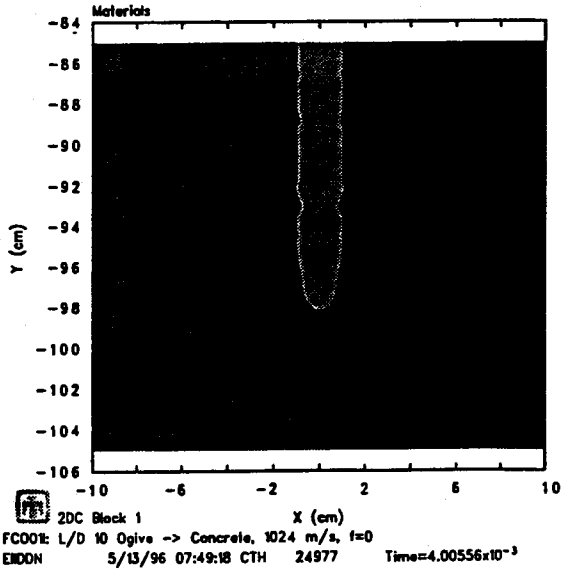
- CTH model removes mass from the surface according to local conditions.
- Data show mass lost is proportional to initial KE. This suggests model shown at right:
- Results agree well with experimental data by Forrestal on mass loss and penetration depth.

$$v = \frac{CVp}{\rho}$$

C=constant

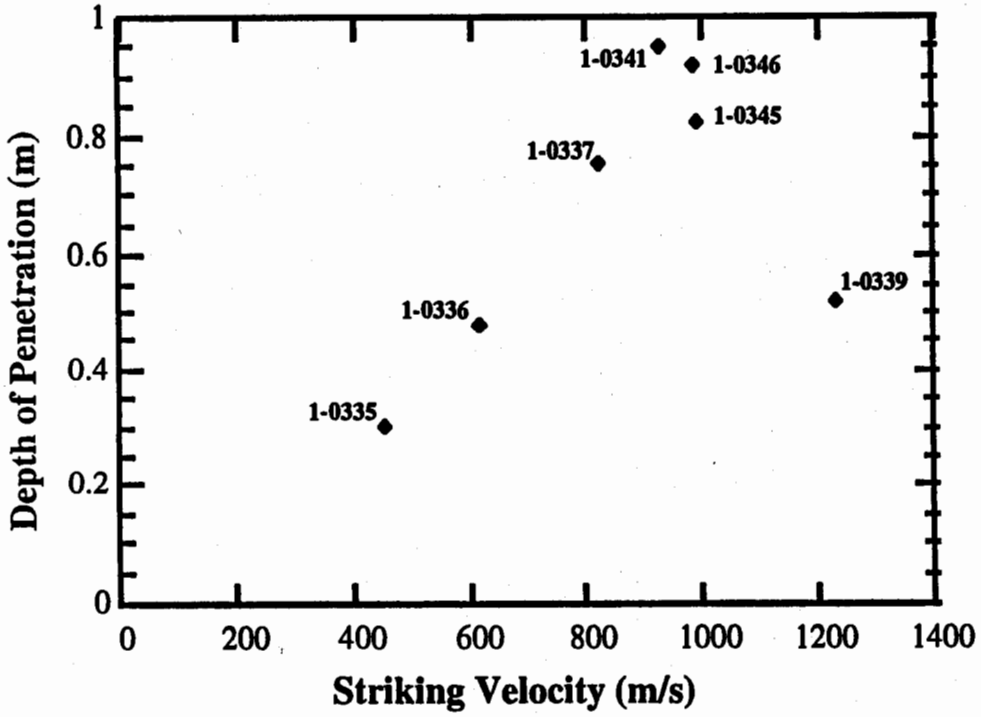


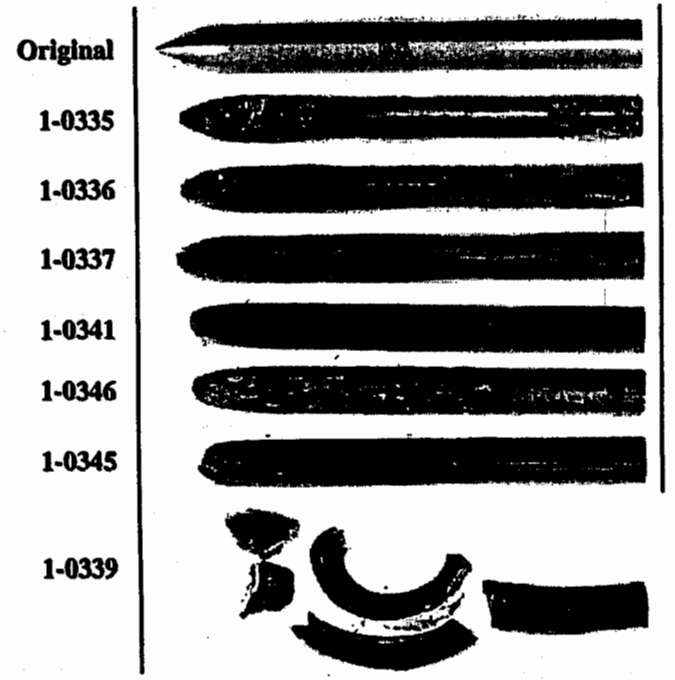




EPW Technology

AISI E4340 SAQ Steel Projectiles into SAC-5 Concrete





ADW CONCEPT ANSWERS
CONCEPT 27 (U)
Existing Nuclear Stockpile Options

J. F. Cuderman, Steve Schafer, Al Baker—Sandia National Laboratories

1. (U) PHYSICAL CHARACTERISTICS

   a. (U) External Dimensions:
   B61-7: 142"long, 13.3" OD; B83: 145"long, 18"OD;
   W80 CM Warhead: 31.5 "long, 12.75" OD.

   b. (U) Case Thickness:
   Not Applicable to non-penetrator systems

   c. (U) Quantity and characteristics of ADW materials:
   Nuclear Package

   d. (U) What is toxicity of the by-products:
   Radiation

   e. (U) What are moments of inertia:
   B61-7: Pitch and Yaw: 819 lb-in^2; Spin: 15,000 lb-in^2
   B83: See Fig. 1

   f. (U) How much HE, if any, and what type:
   Not applicable to nuclear systems since it is not significant part of the ADW material

   g. (U What type of propellant is used:
   Not applicable to these nuclear systems

   h. (U) Overall weight:
   B61-7: 765 lb
   B83: 2467
   W80 CM Payload: 300 lb

2. (U) FUNCTIONAL CHARACTERISTICS

   a (U) Volume or area affected by weapon:
   Depends on yield, height of burst

   b. (U) Effect of dust, debris, and other contaminants:
   Little or none

   c. (U) Weapon outputs associated with each weapon and yield combination: